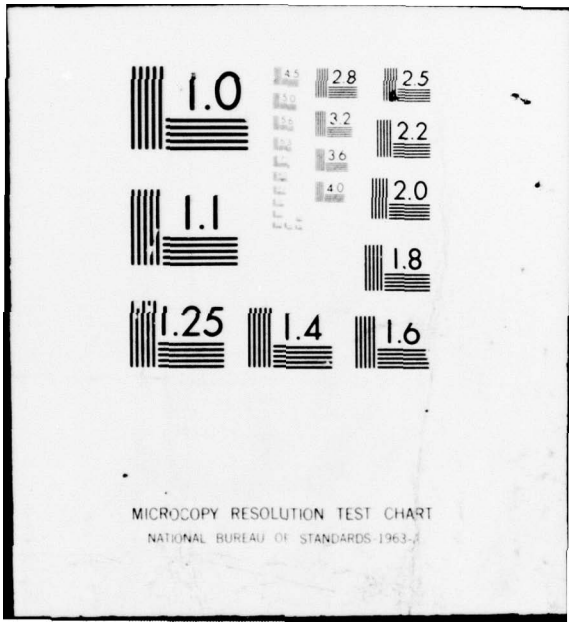
AD-A047 114 CALIFORNIA UNIV SANTA CRUZ INFORMATION SCIENCES F/G 9/2
AUTOMATIC THEOREM PROVING.(U)
MAY 77 S SICKEL N00014-76-C-0681
UNCLASSIFIED NL

| OF |
AD
A047114

END
DATE FILMED
1 -78
DDC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

(12)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle) (6)

Automatic Theorem Proving •

5. TYPE OF REPORT & PERIOD COVERED

Final - 4/1/76 to 3/30/77

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s) (10)

Sharon Sickel

8. CONTRACT OR GRANT NUMBER(s) (15)

N00014-76-C-0681

9. PERFORMING ORGANIZATION NAME AND ADDRESS

Sharon Sickel
✓ Information Sciences, UCSC, Rm. 237 AS
Santa Cruz, Ca. 95064

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS (11)

Office of Naval Research
Arlington, Virginia 22217

12. REPORT DATE

May 31 1977

13. NUMBER OF PAGES

7

14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) (12) 7p.

Office of Naval Research
University of California
553 Evans Hall
Berkeley, California 94720

15. SECURITY CLASS. (of this report)

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) (9)

Final progress rpt.
1 Apr 76 - 31 Mar 77,

18. SUPPLEMENTARY NOTES

DDC
RECEIVED
NOV 30 1977
A

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

AD A047114

AD No. ____
DDC FILE COPY

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-LF-014-6601

410 350

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

LB

FINAL PROGRESS REPORT

Office of Naval Research Contract No. N00014-76-C-0681

Contractor: The Regents of the University of California

Principal Investigator: Dr. Sharon Sickel

Period April 1, 1976 to March 30, 1977

WORK ACCOMPLISHED

Formal Grammars. The Clause Interconnectivity Graph search has been formalized in terms of formal grammars, and results from automata theory have been brought to bear on it. Proofs are automatically describable by formal grammars. In many cases, these formal languages have closed form representations, thereby providing finite descriptions of potentially infinite sets of proofs. An informal coverage [1] of this work was presented at the Canadian CSCSI/SCEIO Summer Conference, held in Vancouver, B.C., August, 1976, and was published in the proceedings of that meeting. The formal version of this work [3] is to be presented and published at the Fifth International Joint Conference on Artificial Intelligence (IJCAI) to be held at MIT in August, 1977.

Programming Methodology. A logic-based programming methodology was developed in collaboration with Keith Clark of Imperial College in London. A philosophy consistent with the reliable software and structured programming of Dijkstra and Hoare was used to

suggest a method of program design and construction. The method allows programs to be specified in a first-order logic and then by several stages formally transformed into a conventional program. The original specification is concise and intuitive and deals with abstract data-type definitions, thereby allowing full data-type definition facilities and avoiding the combination of high-level design with low-level implementation issues. This work will be presented and an extended abstract published at IJCAI in August. Some related work [4] is presented in a local technical report.

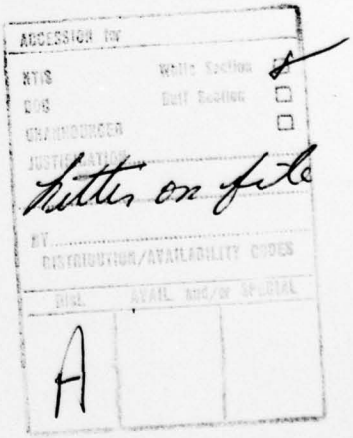
Applications. A paper [5] will be presented at the Workshop on Automatic Deduction, MIT, August 1977 that discusses applications of the above work.

Equality Theorem Proving. Mike Fay, a graduate student in Information Sciences, has been working on the problem of handling the equality predicate in theorem proving. He has devised a method of keeping an equality information base that can be updated and queried by a theorem proving system. He is incorporating the work of Lankford, Knuth and Bendix, and Platkin and is interfacing his system to the Clause Interconnectivity Graph method that is based on compatible uses of variables. This work is being written up as a master's thesis and should be completed summer of '77. It will be distributed to ONR at that time.

Proving Unsatisfiability of Horn Sets. Work was completed in formalizing the restricted case of using clause interconnectivity

graphs on sets of Horn clauses [6]. The class of Horn clause sets constitute a useful subclass of problems. Many problems are naturally expressed as Horn sets, and all problems can be rephrased as a Horn set, although not always conveniently. Some researchers, e.g., Kowalski, contend that all natural and intuitively expressed problems are Horn sets. Previous work has shown that unsatisfiable Horn sets may be proved unsatisfiable in polynomial time, i.e., the time required can be described as a polynomial function of the length of the input. Using the clause interconnectivity graph representation, we have reproved that complexity result in a very simple manner.

Sabbatical. The principal investigator spent four months, beginning in late August, on sabbatical. A sabbatical report is attached.



BIBLIOGRAPHY

1. "A linguistic approach to automatic theorem proving," Proceedings of CSCSI/SCEIO Summer Conference, Vancouver, B.C., 1976.
2. "Predicate logic: a calculus for deriving programs," (with K. Clark), Proceedings of International Joint Conference on Artificial Intelligence, Boston, Massachusetts, 1977.
3. "Formal grammars as logic derivations," Proceedings of International Joint Conference on Artificial Intelligence, Boston, Massachusetts, 1977.
4. "A logic-based programming methodology," Technical report, University of California, Santa Cruz, CA, 1977.
5. "*Formulas for generating plans*," to be presented at Workshop on Automatic Deduction, Boston, Massachusetts, 1977.
6. "Clause Interconnectivity Graphs applied to Horn clause theorem proving," Technical Report, University of California, Santa Cruz, CA, 1977.
7. "Equality in theorem proving" (tentative title), Michael Fay's Master's thesis, University of California, Santa Cruz, CA, 1977.

SABBATICAL REPORT

Sharon Sickel
Information Sciences
Crown College
January 10, 1976

This sabbatical taken fall quarter, 1976, has been busy and fruitful. An itinerary is attached.

During the two-month stay at Imperial College, I had extensive discussions with Robert Kowalski and Keith Clark, co-principal investigators on Science Research Council sponsored research in logic. The main goal of the visit was to gain insight in collaborating with Kowalski. However, Clark and I were able to complete some interesting research and we wrote a paper summarizing those results. That paper is being submitted for the IFIP Congress 77, an international conference on computer science. In addition to that work, I have done the basic research needed for another paper that I will write up after my return. The Imperial visit was especially stimulating because of Kowalski's constant stream of visitors.

My visit at Carnegie-Mellon will be spent mainly discussing theorem proving with Peter Andrews and writing up the formal description of the linguistic approach presented at the CSCSI/SCEIO conference.

The two major visits along with several short visits and the conference have given me the opportunity to talk with many interesting researchers in my field.

8/25-27	University of British Columbia, Vancouver, B.C.	CSCSI/SCEIO Conference
-----	-----	wrote the report on the above conference for the AISB Newsletter (British counterpart to the Sigart Newsletter)
8/29-11/1	Imperial College of Science and Technology, London, England	visit with logic research group including extensive collaboration with Robert Kowalski and Keith Clark
10/6	"	presented Computing and Control seminar
10/18	University of Newcastle Upon Tyne, Newcastle, England	visited Computer Science Dept. and talked mostly to Brian Randall's software reliability group (minus Brian, who is on sabbatical in Toronto)
10/19-20	University of Edinburgh Edinburgh, Scotland	two-day visit to the Dept. of Artifical Intelligence, including brief collaborations with John Reynolds, Rod Burstall, Alan Bundy, and Bernard Meltzer
10/20	"	Artifical Intelligence seminar given
10/25	University of Essex Colchester, England	visit to Computer Science Dept., Pat Hayes in particular
11/1-12/1	Carnegie-Mellon University Pittsburg, Pa	collaborated with Peter Andrews of Dept. of Mathematics and with some members of the Computer Science Dept.
11/9	"	presented Computer Science Dept. Artificial Intelligence seminar
11/8	"	presented Math Dept. graduate theorem proving seminar
11/15	"	"
12/1-12/3	Syracuse University	visit to collaborate with Alan Robinson
12/4-11		visited University of Toronto, Computer Systems Research Group
12/17	Argonne Labs	visit to collaborate with Larry Wos and Larry Henschen

OFFICIAL DISTRIBUTION LIST

Contract N00014-76-C-0682

Defense Documentation Center
Cameron Station
Alexandria, VA 22314
12 copies

Office of Naval Research
Information Systems Program
Code 437
Arlington, VA 22217
2 copies

Office of Naval Research
Code 102IP
Arlington, VA 22217
6 copies

Office of Naval Research
Code 200
Arlington, VA 22217
1 copy

Office of Naval Research
Code 455
Arlington, VA 22217
1 copy

Office of Naval Research
Code 458
Arlington, VA 22217
1 copy

Office of Naval Research
Branch Office, Boston
495 Summer Street
Boston, MA 02210
1 copy

Office of Naval Research
Branch Office, Chicago
536 South Clark Street
Chicago, IL 60605
1 copy

Office of Naval Research
Branch Office, Pasadena
1030 East Green Street
Pasadena, CA 91106
1 copy

New York Area Office
715 Broadway - 5th Floor
New York, NY 10003
1 copy

Naval Research Laboratory
Technical Information Division
Code 2627
Washington, DC 20375
6 copies

Dr. A. L. Slafkosky
Scientific Advisor
Commandant of the Marine Corps (CodeRD-1
Washington, D. C. 20380
1 copy

Naval Electronics Laboratory Center
Advanced Software Technology Division
Code 5200
San Diego, CA 92152
1 copy

Mr. E. H. Gleissner
Naval Ship Research & Development Center
Computation and Mathematics Department
Bethesda, MD 20084
1 copy

Captain Grace M. Hopper
NAICOM/MIS Planning Branch (OP-916D)
Office of Chief of Naval Operations
Washington, D. C. 20350
1 copy

Mr. Kin B. Thompson
Technical Director
Information Systems Division (OP-911G)
Office of Chief of Naval Operations
Washington, D. C. 20350
1 copy


78